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SOME SIMPLE PHYSIOLOGICAL APPARATUS

By George E. Stone

The writer has for many years conducted a physiological practicum connected with botanical teaching, and as might be expected in any course requiring experiments, many methods and devices have been incidentally developed, some of which have proved fairly satisfactory in demonstrating certain principles, and others may find them suggestive in their lines of work.

Method of Demonstrating Difference in Transpiration Between Upper and Lower Sides of the Leaf

For demonstrating the difference in transpiration between the upper and lower sides of the leaves we have used the apparatus shown in figures 1 and 2, which illustrate a calla plant with the apparatus in place. It consists of two simple hygrometers 5 cm. in diameter, similar to those often used in cigar cases. These are attached to two pieces of metal tubing slightly larger in diameter than the hygrometers, each tube being about 4.5 cm. long. The hygrometers are placed in the end of each tube by means of rubber sheeting cut so as to fit tightly around the hygrometers. The rubber is then turned over the end of the metal and tied on with a thread. The tubes containing the hygrometers are placed on either side of the leaf, the ends of the tubes being supplied with rubber rings or bands so that the two halves of the metal cylinder, each containing the hygrometer, can be pressed against the leaf firmly but without injuring it. Glass tubes or even large corks may be substituted for metal if the proper size is obtainable. By taking readings of both hygrometers at the beginning of the experiment and at different times afterwards the relative difference in the transpiration between the upper and lower sides of the leaf is fairly accurately determined.

Method of Demonstrating the Effects of Various Factors on Transpiration

There are many simple experiments which may be done to illustrate the effects of various factors on transpiration. In our

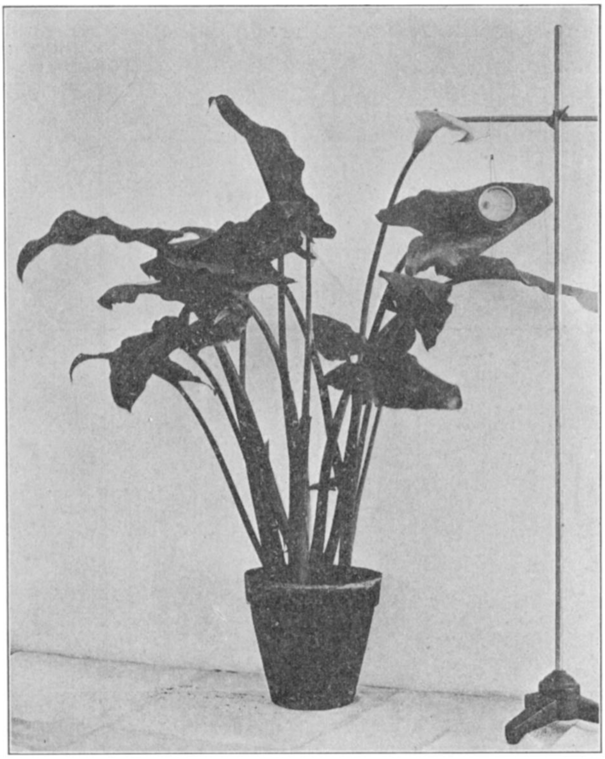

FIG. 1. Method of demonstrating the difference in transpiration between the upper and under side of the leaf by means of hygrometers.

laboratory we have for a number of years made use of the apparatus illustrated in figure 3, which consists of a wooden stand mounted on legs, as shown in the illustration. This stand supports a large bell glass containing two apertures and in the center of the wooden stand there is a hole about one-half inch in diameter through which the plant is inserted into a tube below. The stem of the plant is forced down through the cork stopper into the tube containing water. A piece of flexible rubber cloth is tied around the bottom of the bell glass. The stem of the plant is put through a slit in the rubber cloth which is fastened to the plant securely by means of thread. From the lower end of the larger tube containing the stem of the plant there are two small glass tubes bent at right angles at the extreme end which are attached to a meter stick, the lower ends of which are submerged in a vessel of water. One of these tubes has a calibre of about three millimeters in diameter; the other of about one millimeter or more. If the plant is transpiring very

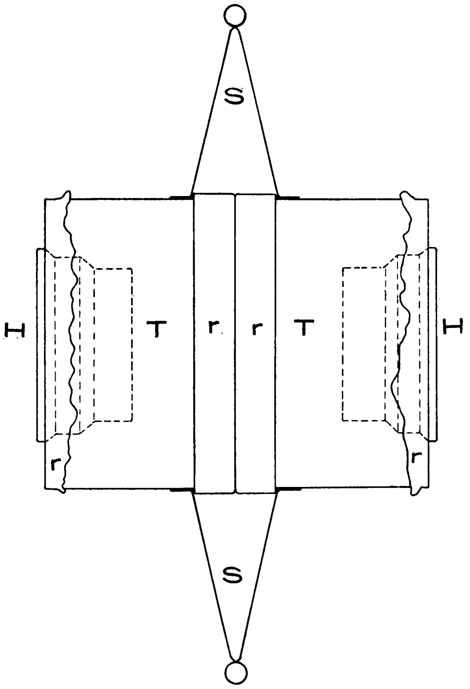

Fig. 2. Cross-section of transpiration apparatus. *T*, Metal tubes holding hygrometers. *H*, Hygrometers. *S*, Springs which hold the tubes close to the leaf. *r*, Rubber sheeting and bands.

freely the larger tube can be used, but if transpiring only slightly the smaller one will answer the purpose better. Connected with the large tube containing the stem is a reservoir or supply of water which is for the purpose of enabling the bubble to be placed anywhere on the scale desired by letting in water or by sucking it upwards. We have used this apparatus now for many years with considerable success. For our purpose we attach the bell-glass to a Chapman aspirator which enables one to draw air of various degrees of saturation through the chamber, and by means of the bubbles the rate of transpiration can be determined. One can demonstrate the effects of ordinary laboratory air on transpiration or the effects of dry and moist air. The effects of dry air may best be determined by aspirating through sulfuric acid, which is much superior to calcium chloride. The effects of moist air may so be demonstrated by passing the air through water bottles, and the effects of warm air by heating very thoroughly a piece of gas pipe over a flame and aspirating air through it. In carrying on the various experiments a thermometer and hygrometers may be placed under a bell-glass to indicate the changes in the air. This apparatus may be used to demonstrate the effects of chloroform, ether, illuminating gas, etc. on transpiration, and by the use of a simple mechanism the effects of movements or vibrations on the plant in the bell-glass may be determined, and in short, this apparatus may be used to demonstrate most of the fundamental factors underlying transpiration.

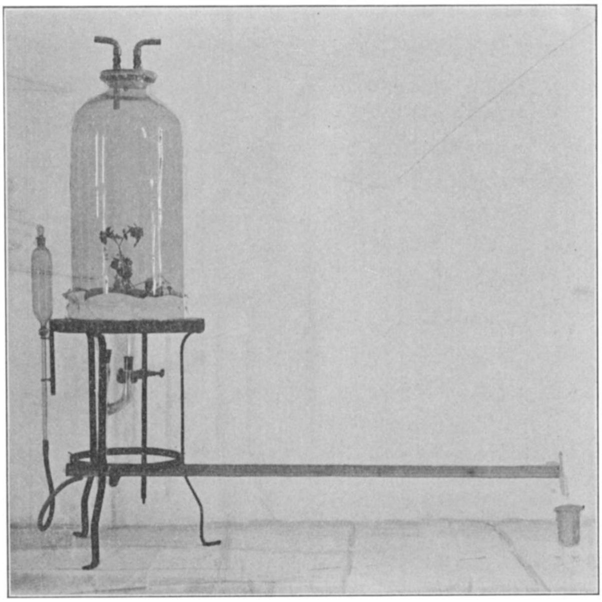

FIG. 3. Method of demonstrating effects of various factors on transpiration.

DEVICES FOR PERCOLATING AIR THROUGH SOILS

There is on the market a standard set of appliances adapted to the study of soil physics. Simple experiments to demonstrate the percolation of air and water through soils, capillarity, water retaining capacity, etc., are of value in connection with the study of respiration. An appliance is often used in connection with the experiments relating to the percolation of air through soils which is defective and unreliable, and the writer has made use for a number of years of a form similar to that shown in figure 4. The principles underlying the present device for demonstrating the percolation of air through soils are not perfect, but the defects are of more theoretical than practical importance and could be easily remedied if necessary. The device

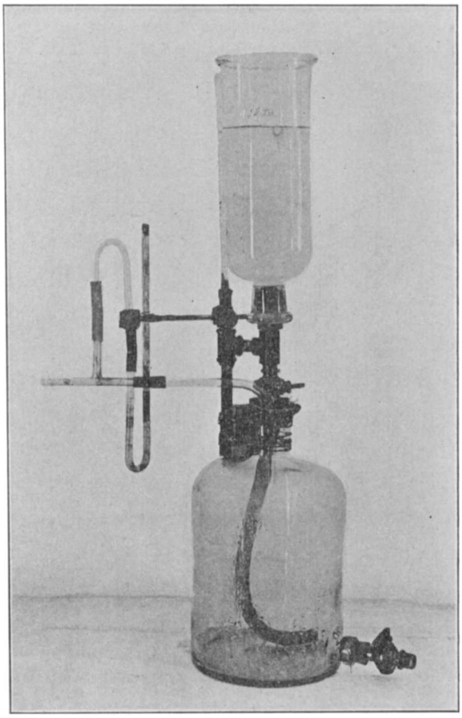

FIG. 4. Device for percolating air through soils.

consists of a bottle holding about two gallons with an opening at the bottom provided with a valve. This is connected with a bell-jar overhead holding about a liter and a half, and in the operation one liter of water is allowed to pass very slowly from the jar above into the lower one. This causes a displacement of air; in other words, one liter of air in the lower jar is forced out through the tube shown at the left into the soil and the length of time it takes this liter of air to pass through certain soils is recorded. By using soils of different texture different values are obtained. The soils in an experiment of this nature are usually placed in metal cylinders of about 500 c.c. capacity, but lamp chimneys provided with corks at the bottom may be substituted, if necessary.

Connecting the tube with the lower jar there is a water manometer containing an inch or two of water in each arm, which determines the pressure of the air due to resistance to pressure through the soil, and when one liter of air is passed from the upper bell-jar into the jar below and the water columns remain precisely on a level, exactly one liter of air has been passed through the soil. The contrivances often used for this purpose are so clumsy and constructed on such poor mechanical principles that it is impossible to get the same results from the same soil twice, but by the use of the device described above, very reliable results are obtainable.

MASSACHUSETTS AGRICULTURAL COLLEGE.

Mr. J. A. Udden, of Rock Island, Illinois, reports in *Science* for July 31, a fossil cycad found in the Upper Cretaceous of Texas Eight fragments of what was presumably the same silicified trunk were found, three of these matched by their fractures and showed a stem about ten inches wide, hollow, and considerably flattened.

The *Century* for September has an illustrated article on the Future Wheat Supply of the United States, written by Edward C. Parker, Assistant at the Agricultural Experiment Station of the University of Minnesota. The methods of the wheat breeder are clearly described, and besides the economic information indicated by the title the article contains a discussion of spring and winter wheats, rotation of crops, etc.

The Forest Service has issued a bulletin announcing that the supply of dogwood and persimmon in the southern States is nearly exhausted. These woods furnish, it is said, the entire supply of bobbins, shuttles, and spindles used in the cotton and woolen mills. Dogwood is said to be the only wood which takes a high polish and wears perfectly smooth by friction under water. Two large plants for the manufacture of bobbins and shuttles have been erected in Oregon, where the dogwood forests are the greatest in the world, the trees often reaching a height of 75 feet. Eastern manufacturers, however, are trying to find satisfactory substitutes nearer home, the most promising of which is probably the tupelo gum.

The *New York Tribune* announces that visitors to California will "have access to a third forest of giant redwoods when the counties of Tulare and Fresno complete construction of twenty-five miles of highway between Visalia and Redwood Canyon, in the Kings River country, where there is a grove of over fifteen thousand magnificent specimens of the Sequoia gigantea, many of which are said to compare in size and beauty with the trees of the Mariposa and Calaveras groups. It is probable that the property, which is as yet untouched by lumbermen, will be recommended to Congress for purchase as a national park. One tree in the redwood grove, recently measured by a government ranger, is 110 feet in circumference and is estimated to contain 800,000 feet of lumber. A claim is made that a fallen giant in the region is the largest in the country. Located at an altitude of less than six thousand feet, the canyon would be accessible for a longer period than the other giant groves in the state."

The *Plant World* for June contains a paper on stomata by Professor Francis E. Lloyd. The study upon which the article is based extended over the major part of three years. In order to determine the relation between transpiration and the size of the openings, "it is necessary to be able to determine the rate of transpiration and the size of the stomatal openings independently at the same instant of time. It is obvious that we may neither judge the rate of transpiration from the size of the openings, nor the size of the openings from the rate of transpiration. 'How to do this was the difficult task, but with a sufficiently small error, this was done in the following manner :

"It was found that the stomata of certain, and probably many, plants may be fixed in the form in which they are found in life by tearing off the epidermis and plunging it into absolute alcohol. The distortion of the stomata caused by the tearing is only temporary, the guard cells recovering their form just as a rubber ball does when it has been released from pressure. The alcohol extracts the water from the cell-walls, thus rendering them rigid, and this it does so rapidly that they do not have a chance to lose the water contained within the protoplast while the walls are still pliable, a process which would result in closure."

Many series of experiments, mostly with the ocotillo, *Fouquieria splendens*, under varying conditions as to light, heat, humidity, etc., have led Professor Lloyd to the following conclusions: "With little or no movement in the stomata, and therefore with little change in the size of their openings, wide fluctuations in the rate of transpiration may and do occur ;" and further, the evidence now in hand on the plants studied does not support the view that stomata are regulators of transpiration. "These are not markedly desert types as far as the stomata are concerned, and the amount of water-vapor which may escape through one type of stoma per unit of time may be greater or less than that which may escape through another type. The structure of the stoma, as that of other organs, may indeed explain why some plants are able to get along in the desert, and others not. Stomata of a given form may act as a dampener on transpiration, just as, using an analogy, the mute in a cornet reduces the amount of sound which emerges from the instrument. But the mute does not regulate the sound, causing now more and now less in successive intervals of time. In this sense, also, stomata cannot be said to regulate the flow of water-vapor from the leaf. Nor do they 'anticipate' wilting, the closure of stomata during this process being as much a result of the wilting as the flaccidity of the other cells of the leaf. We must therefore give up for the present the long cherished notion that stomata are delicate valves opening and closing rapidly to modify the rate of transpiration as the needs of the plant indicate."

An interesting article on the manufacture and consumption of pulp wood* is given in *Science* for July 24: "The advance statement is made from the statistics collected by the Census Bureau in coöperation with the United States Forest Service. Many of the figures bring out interesting facts which show the rapid growth of the paper-making and allied industries during the last decade. Nearly four million cords of wood, in exact numbers 3,962,660 cords, were used in the United States in the manufacture of paper pulp last year," and over "two and one half million tons of pulp were produced. The pulp mills used 300,000 more cords of wood in 1907 than in the previous year. The amount of spruce used was 68 per cent. of the total consumption of pulp wood, or 2,700,000 cords. The increased price of spruce has turned the attention of paper manufacturers to a number of other woods, hemlock ranking next, with 576,000 cords, or 14 per cent. of the total consumption. More than 9 per cent. was poplar, and the remainder consisted of relatively small amounts of pine, cottonwood, balsam and other woods. There was a marked increase last year in the importation of spruce, which has always been the most popular wood for pulp. For a number of years pulp manufacturers of this country have been heavily importing spruce from Canada, since the available supply of this wood in the north-central and New England States.

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*According to the New York Tribune for September 18, the Congressional committee appointed to investigate conditions in the paper mill and pulp industry reports plenty of pulp wood in the Middle West. One of the most important witnesses interviewed was William S. Taylor, president of the Pulp Wood Supply Company of Appleton, which organization furnishes pulp wood for twelve of the paper mills in the Fox River Valley; he stated that "his company buys about 225,000 cords of pulp wood annually, about 50 per cent. being spruce, most of which is purchased in Minnesota, and about 50 per cent. being hemlock, all of which is purchased in Wisconsin." Mr. Taylor is confident that "neither the present nor the coming generation need have any worry about the supply of pulp in the Middle West, for there are millions upon millions of feet available.".

where most of the pulp mills are located, is not equal to the demand."

The statement is made that only a "slightly greater amount of domestic spruce was used than in 1906. Large quantities of hemlock were used by the Wisconsin pulp mills, and the report shows that the Beaver State now ranks third in pulp production, New York and Maine ranking first and second, respectively, Poplar has been used for a long time in the manufacture of high-grade paper, but the supply of this wood is limited and the consumption of it has not increased rapidly. Wood pulp is usually made by either one of two general processes, mechanical or chemical. In the mechanical process the wood, after being cut into suitable sizes and barked, is held against revolving grindstones in a stream of water and thus reduced to pulp. In the chemical process the barked wood is reduced to chips and cooked in large digesters with chemicals which destroy the cementing material of the fibers and leave practically pure cellulose. This is then washed and screened to render it suitable for paper making. The chemicals ordinarily used are either bisulphite of lime or caustic soda. A little over half of the pulp manufactured last year was made by the sulphite process, and about one third by the mechanical process, the remainder being produced by the soda process. Much of the mechanical pulp, or ground wood, as it is commonly called, is used in the making of newspaper. It is never used alone in making white paper, but always mixed with some sulphite fiber to give the paper strength. A cord of wood ordinarily yields about one ton of mechanical pulp or about one half ton of chemical pulp."

NEWS ITEMS

Dr. Raymond H. Pond has been appointed biologist of the Metropolitan Sewerage Commission of New York.

The death of Dr. Hermann Settegast, aged ninety years, professor of agriculture at Berlin, has recently been announced.

Miss Margaret A. Kingsley, a graduate of Smith College, 1908, has been appointed assistant in botany at Barnard College, Columbia University.